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Prevalence of the persistent median artery in patients undergoing surgical open carpal tunnel release: A case series

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ABSTRACT

Background: Carpal tunnel syndrome is a common condition in adults with an estimated prevalence of up to 5% in the general population. The presence of a persistent median artery is an important consideration for plastic and orthopedic surgeons who frequently perform carpal tunnel release. This artery may persist into adulthood and constitute a significant supply of blood to the hand, sometimes compressing the median nerve.
Purpose: In this case series, we describe the prevalence of the persistent median artery identified intraoperatively in Polish subjects undergoing surgical open carpal tunnel release.
Methods: The data regarding the prevalence of persistent median artery were retroactively collected post-operatively from the standard surgical protocols.
Results: Persistent median artery was identified in 36 out of 1285 operated hands (2.8%). The observed PMAs were identified in 15 (2.0%) cases out of 750 right upper limbs and in 21 (3.9%) cases out of the 535 left upper limbs.
Conclusions: Persistent median artery can be present in the operating field of any surgeon that performs carpal tunnel release and any other surgical procedures in the wrist region. Therefore awareness of its presence is crucial to minimize intraoperative complications such as bleeding or digital ischemia.

1. Introduction

The median artery is an embryological structure that represents the main blood supply to the hand during the first trimester of embryonic development [1]. It typically regresses after the eighth week of intrauterine life when the radial and ulnar arteries arise and dominate the blood supply to the hand [1].

According to Natsis et al. (2009), if present, the persistent median artery (PMA) is the main supply of blood to the median nerve. This artery may persist into adulthood and cause symptoms consistent with median nerve disturbances; either by compression when accompanying the median nerve through the carpal tunnel or iatrogenic ischemia. It was found that there is variable prevalence amongst different ethnic populations. This variegated prevalence may be due to the variation in alleles that control this anatomical anomaly [2].

Carpal tunnel syndrome is a common condition in adults with an estimated prevalence of up to 5% in the general population with women understood to be affected more than men [3]. Obesity and excessive wrist use in the workplace are both considered to be possible risk factors for CTS [4]. Chronic diseases and comorbid conditions, particularly diabetes mellitus, rheumatoid arthritis and hypothyroidism are thought to increase the incidence of CTS in these individuals [5,6]. Several studies have implicated a bifid median nerve and a persistent median artery as potential risks for CTS [7–10]. Thus, it is important to be aware of these structural variations when planning surgical procedures of the wrist. The use of color Doppler ultrasonography at high frequencies has been demonstrated to be a useful diagnostic tool in patients with CTS [11,12] to evaluate PMA.

The presence of a PMA is an important consideration for plastic and orthopedic surgeons who frequently perform open carpal tunnel release; mostly due to mechanical compression of the median nerve by PMA (Fig. 1). Also, given that the PMA is the main supply of blood to the

Abbreviations: PMA, Persistent Median Artery; CTS, Carpal Tunnel Syndrome; EDX, Electrodiagnostic studies; NCS, Nerve Conduction Studies; EMG, Electromyography; TCL, Transverse Carpal Ligament; SPA, Superficial Palmar Arch.

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median nerve it follows that the compromise of the PMA in these individuals can result in ischemia of the median nerve unless collateral blood supply is certain (Natsis et al., 2009). Accidental perforation of the vessel due to lack of awareness of its presence or its use for making graft arteries (Natsis et al., 2009) are also important applications of this case series. Thus far there has been no large intraoperative study on Polish populations. It was therefore our aim to identify the prevalence of PMA in individuals of Polish descent in a large-scale intraoperative setting. In this case series, we describe the prevalence of the persistent median artery identified intraoperatively in Polish subjects undergoing surgical decompression for carpal tunnel syndrome.

2. Materials and methods

2.1. Sample

This retroactive study looks at the data of 1285 cases of CTS (hands) which were operated on by a single surgeon (first author). This includes 463 men and 822 women. All of the individuals enrolled were Polish nationals and the range of ages was 19–48 years old. These cases were recorded between 2000 and 2020 at the Plastic Surgery Department of the Postgraduate Medical Center in Warsaw (421 cases) and between 2000 and 2012 at the NZOZ Hippocrates Clinic in Warsaw (864 cases). Patients with typical symptoms of CTS underwent electrodiagnostic studies (EDX). EDX testing included nerve conduction studies (NCSs) and electromyography (EMG). Based on these studies individuals were qualified as cases to be included in this study. There were no exclusion criteria involved in sample selection. The data about the prevalence of PMA were retroactively collected post-operatively from the standard surgical protocols.

2.2. Clinical and electrophysiological evaluation

As mentioned previously, individuals who presented symptoms typical for CTS underwent EDX evaluation to confirm clinical diagnosis [13–17]. Ultrasound examination was not routinely ordered and EDX studies of the median and ulnar nerves were performed irrespective of whether or not the patient presented a previously performed ultrasound image. EDX studies were performed by a qualified electromyography technician in a clinical electrodiagnostic unit. The interpretation of the EDX results was the role of the plastic surgeon who was also the primary surgeon in this study.

2.3. Open carpal tunnel release

In each patient open carpal tunnel release was performed under regional anesthesia using peripheral nerve block at the volar aspect of the wrist and palm. A longitudinal Tanzer incision was made over the carpal tunnel along the radial border of the extended ring finger and extended distally to expose the transverse carpal ligament (TCL). After complete TCL transection, a bifid median nerve was identified and accompanied by an accessory artery, the persistent median artery, which lied in between the two nerve bundles. Mean diameter of the PMA, as measured intraoperatively after release of ischemia, was at least 3.00 mm. In three cases a thrombus in the median artery was found. The excision of the thrombosed segment of the artery was made after ensuring a sufficient blood supply to the fingers.

2.4. Statistical analysis

Statistical analysis was performed using the SPSS for Windows (ver. 25.0, IBM, USA) software package. The elements of the descriptive statistics have been calculated. Moreover, the categorical variables were analyzed using the Chi-squared test. A P value < 0.05 was taken to indicate statistical significance.

3. Results

Among the 1285 patients the persistent median artery was identified in 36 cases, that constituted 2.8% of all operated hands diagnosed with CTS. Only 2 males (0.5%) had the PMA, whereas it was identified in 34 women (4.1%). This difference was statistically significant. Among 826 dominant hands operated, in 16 hands (1.9%), the PMA was visualized. Additionally, the 20 cases (4.4%) of the PMA were identified

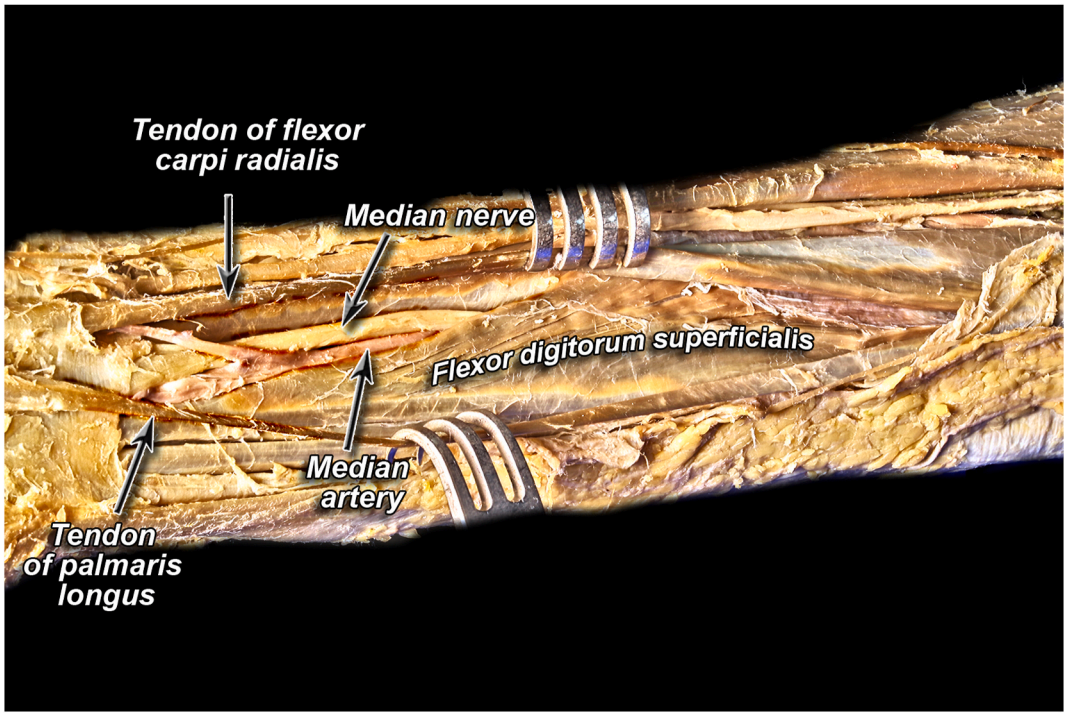

Fig. 1. Persistent median artery on cadaveric dissection. Courtesy of the Department of Anatomy, Jagiellonian University Medical College, Cracow, Poland.

intraoperatively among 459 non-dominant (auxiliary) hands, which was significantly higher than among patients with dominant hands operated. The observed PMAs were identified in 15 (2.0%) cases out of 750 right uuper limbs and in 21 (3.9%) cases out of the 535 left upper limbs.

The average age of patients with this anomaly was 33.1 years of age. Most of the cases with PMA were in individuals involved in office work with a minority working in manual labour.

4. Discussion

This case series highlights the intraoperative prevalence of PMA (2.8%) in subjects undergoing open decompression for CTS. Persistent median arteries with diameters ranging between 1.0 and 1.5 mm are typically asymptomatic [18]. There is no evidence suggesting that a persistent median artery may result in CTS, *per se*. Importantly, a persistent median artery could be an independent risk factor for CTS when enlarged to 3 mm in diameter in some pathological conditions such as the presence of an internal thrombus, aneurysm or calcified plaque formation [19–21]. The persistent median artery tends to coexist with a bifid median nerve, and the persistent median vein sometimes runs parallel to the persistent median artery. Their positional relationship in the carpal tunnel is uncertain, and thus, preoperative ultrasound is necessary. Thrombosis of the PMA can mimic CTS and the PMA was thrombosed in 3 of our cases and required PMA resection with ligation of both stumps. After a literature review its clear that most studies on this topic to date are either cadaveric [1,22–24] or ultra-sonographic derived [25–27]. Other diagnostic methods used to confirm presence of PMA and/or thrombosis within the PMA include CT angiography [28] and MRI [29]. This case series is unique in that it highlights the prevalence of PMA in living Polish subjects undergoing open surgical decompression for CTS in a large-scale intraoperative setting over the course of twenty years. This large-scale, long-term study should serve to increase the orthopedic, plastic or peripheral neurosurgeon's awareness of this vessel to prevent iatrogenic injury whilst performing CTS release and indeed any other procedure involving the wrist area. Also, as mentioned previously the presence of a thrombosed PMA [24,25] or any other pathology involving the artery that perforates the median nerve can indirectly injure the median nerve. Example of this include calcification [30], arteriovenous malformation [31] or trauma [32] of the PMA. Direct, mechanical injury can be caused by dilatation of the artery with compression on the median nerve [33] which may restrict proper blood circulation within the median nerve causing paresthesia, pain in the forearm or at the wrist and thus subsequently producing symptoms which can mimic CTS (usually acute). It is therefore important to report, retrospectively, the prevalence of similar cases. According to Barfred et al., a PMA with an external diameter of more than 2.0 mm can cause mechanical median nerve compression [34].

Although, this vessel is rarely observed and usually regressed, some authors distinguished anatomical variants of the PMA depending on the anatomical relationship with the radial/ulnar artery and superficial palmar arch [23,35] or its position relative to the surfaces of the median nerve [23]. According to previous findings, the most often observed variants of the SPA (where PMA was present) include median-ulnar arch, radial-median-ulnar arch and radial-median arch [35].

There are some limitations to this study. Firstly, the data was retroactively collected. However, it is important to consider that all the data was collected from operations performed by the same surgeon ensuring standard and systematic recording of the presence of PMA in the operating room. Secondly, the data is limited to patients with CTS solely, but considering the prevalence of PMA is not very high in the overall population this would not have a huge impact on the accuracy of the data collected.

5. Conclusions

The persistent median artery is one of the rare etiologies of carpal tunnel syndrome by increasing pressure on the median nerve [36]. It can be present in the operating field of any surgeon that performs surgical decompression of CTS and therefore awareness of its presence is crucial to minimize intraoperative complications such as bleeding or digital ischemia [37]. Patients should undergo ultrasound scanning of the wrists prior to surgery to avoid accidentally injuring this anatomic variation, thereby improving surgical outcomes [38].

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Ethical statement

Not applicable for this study.

Declaration of competing interest

None.

CRediT authorship contribution statement

Katarzyna Osiak: Conceptualization, Methodology, Data aquisition, Writing - original draft, preparation. **Pierre Elnazir:** Writing - review & editing, Formal analysis. **Agata Mazurek:** Writing - review & editing. **Artur Pasternak:** Supervision, Writing - review & editing.

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